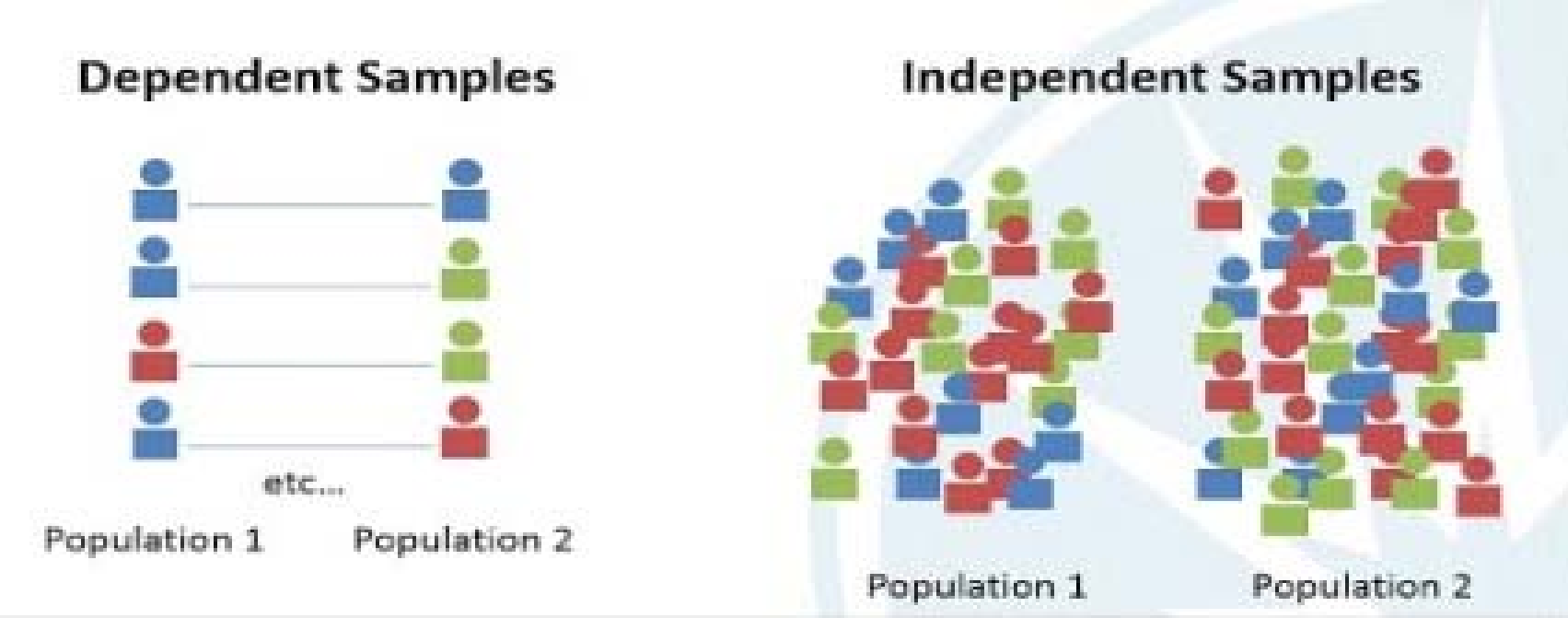
T-TEST WITH DEPENDENT SAMPLES AND REPEATED MEASURES ANOVA (WITHIN SUBJECTS DESIGN), EFFECT SIZE

TOSIN

What can the T-test tell you?

The t-test tells us if there is a **statistically significant difference** between the **mean values** of **two data set**

Dependent and Independent samples



We analyse the mean difference μd

We analyse the difference of the means: μ1-μ2

https://faculty.elgin.edu/dkernler/statistics/ch11/11-2.html

Dependent T-test (within-subjects or repeated-measures) Statistical test

Measured @ Time T1

Measured @ Time T2

- ✓ Same participants
- ✓ Same dependent variable
- ✓ Same condition/treatment

Assumptions

- ✓ **Level of Measurement**
- The dependent variable must be continuous (interval/ratio).
- ✓ **Independence**
- The observations are independent of one another.
- ✓ **Normality**
- The dependent variable should be approximately normally distributed.
- ✓ **Outliers**
- The dependent variable should not contain any outliers.

Dependent Sample

Research question : Is there a statistically significant difference in graduate student's scores on a statistics assessment before and after participating in a one week online statistics workshop.

Ho ; There is no statistically significant difference in graduating student scores on a statistics assessment before and after participating in a one week online statistics workshop

Graduate student
Pre-test scores

Graduate student
Post-test scores

https://www.youtube.com/watch?v=TCqVAtlFhN8

Independent Sample t-test : Data set

Step 1: Calculate the t-value

Before Treatment	After treatment	Difference (After-Before)
4	5	1
1	3	2
3	2	-1
5	2	-3
6	8	2
2	4	2
6	7	1
4	6	2
5	3	-2
6	5	-1

$$t = \frac{\mu_D \sqrt{n}}{S_D}$$

Where μ_D = **Mean difference**

S_D = **Standard Deviation**

n = **Number of sample**

https://www.youtube.com/watch?v=TCqVAtlFhN8

Independent Sample t-test :Data set

Step 2 : Use the t-table to find (cut-off) t

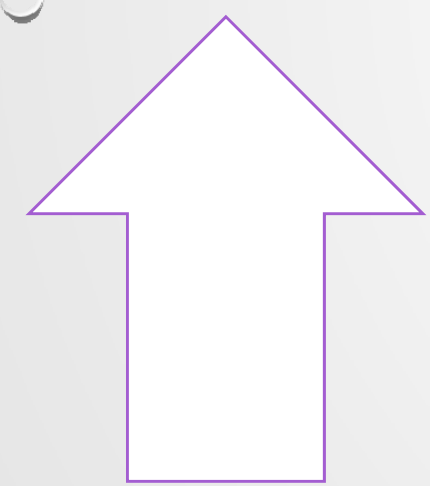
df/p	0.40	0.25	0.10	0.05	0.025	0.01	0.005	0.0005
1	0.324920	1.000000	3.077684	6.313752	12.70620	31.82052	63.65674	636.6192
2	0.288675	0.816497	1.885618	2.919986	4.30265	6.96456	9.92484	31.5991
3	0.276671	0.764892	1.637744	2.353363	3.18245	4.54070	5.84091	12.9240
4	0.270722	0.740697	1.533206	2.131847	2.77645	3.74695	4.60409	8.6103
5	0.267181	0.726687	1.475884	2.015048	2.57058	3.36493	4.03214	6.8688
6	0.264835	0.717558	1.439756	1.943180	2.44691	3.14267	3.70743	5.9588
7	0.263167	0.711142	1.414924	1.894579	2.36462	2.99795	3.49948	5.4079
8	0.261921	0.706387	1.396815	1.859548	2.30600	2.89646	3.35539	5.0413
9	0.260955	0.702722	1.383029	1.833113	2.26216	2.82144	3.24984	4.7809
10	0.260185	0.699812	1.372184	1.812461	2.22814	2.76377	3.16927	4.5869
11	0.259556	0.697445	1.363430	1.795885	2.20099	2.71808	3.10581	4.4370
12	0.259033	0.695483	1.356217	1.782288	2.17881	2.68100	3.05454	43178
13	0.258591	0.693829	1.350171	1.770933	2.16037	2.65031	3.01228	4.2208
14	0.258213	0.692417	1.345030	1.761310	2.14479	2.62449	2.97684	4.1405
15	0.257885	0.691197	1.340606	1.753050	2.13145	2.60248	2.94671	4.0728
16	0.257599	0.690132	1.336757	1.745884	2.11991	2.58349	2.92078	4.0150
17	0.257347	0.689195	1.333379	1.739607	2.10982	2.56693	2.89823	3.9651
18	0.257123	0.688364	1.330391	1.734064	2.10092	2.55238	2.87844	3.9216
19	0.256923	0.687621	1.327728	1.729133	2.09302	2.53948	2.86093	3.8834
20	0.256743	0.686954	1.325341	1.724718	2.08596	2.52798	2.84534	3.8495
21	0.256580	0.686352	1.323188	1.720743	2.07961	2.51765	2.83136	3.8193
22	0.256432	0.685805	1.321237	1.717144	2.07387	2.50832	2.81876	3.7921
23	0.256297	0.685306	1.319460	1.713872	2.06866	2.49987	2.80734	3.7676
24	0.256173	0.684850	1.317836	1.710882	2.06390	2.49216	2.79694	3.7454
25	0.256060	0.684430	1.316345	1.708141	2.05954	2.48511	2.78744	3.7251
26	0.255955	0.684043	1.314972	1.705618	2.05553	2.47863	2.77871	3.7066
27	0.255858	0.683685	1.313703	1.703288	2.05183	2.47266	2.77068	3.6896
28	0.255768	0.683353	1.312527	1.701131	2.04841	2.46714	2.76326	3.6739
29	0.255684	0.683044	1.311434	1.699127	2.04523	2.46202	2.75639	3.6594
30	0.255605	0.682756	1.310415	1.697261	2.04227	2.45726	2.75000	3.6460
z	0.253347	0.674490	1.281552	1.644854	1.95996	2.32635	2.57583	3.2905
CI	———	———	80%	90%	95%	98%	99%	99.9%

Degree of freedom = N-1

Alpha = 0.05

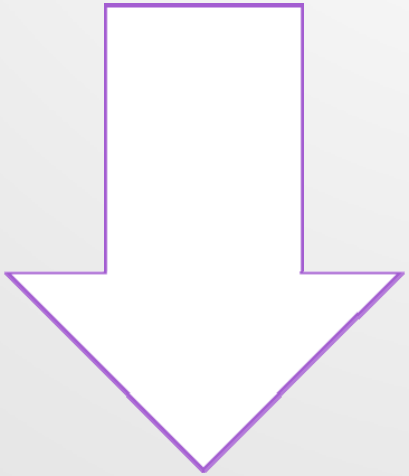
Independent Sample t-test :Data set

Step 3 : State result and Conclude



Reject

Examine the value in relation to the Critical value

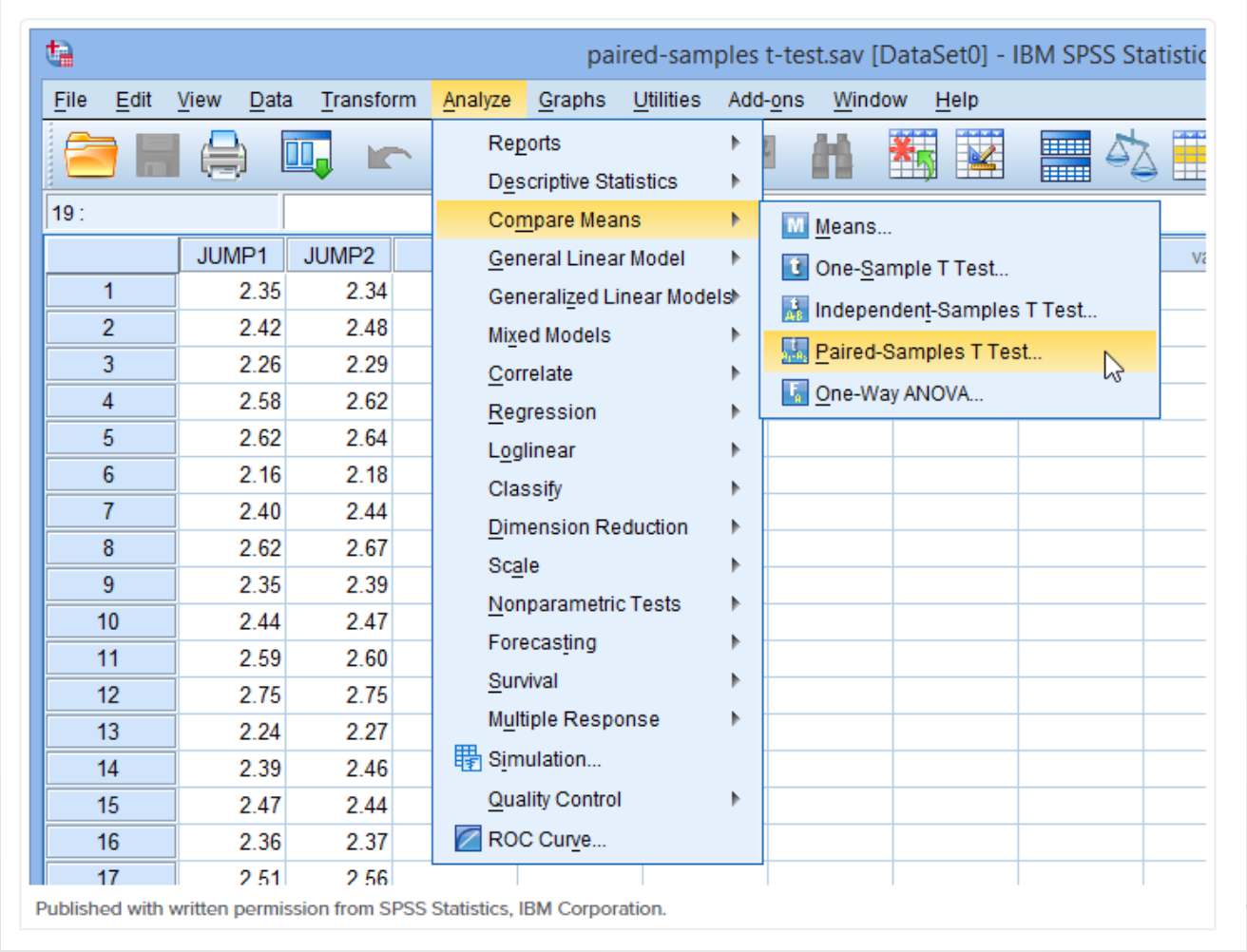


Fail to Reject

https://www.youtube.com/watch?v=TCqVAtIFhN8

Independent Sample t-test :Using SPSS

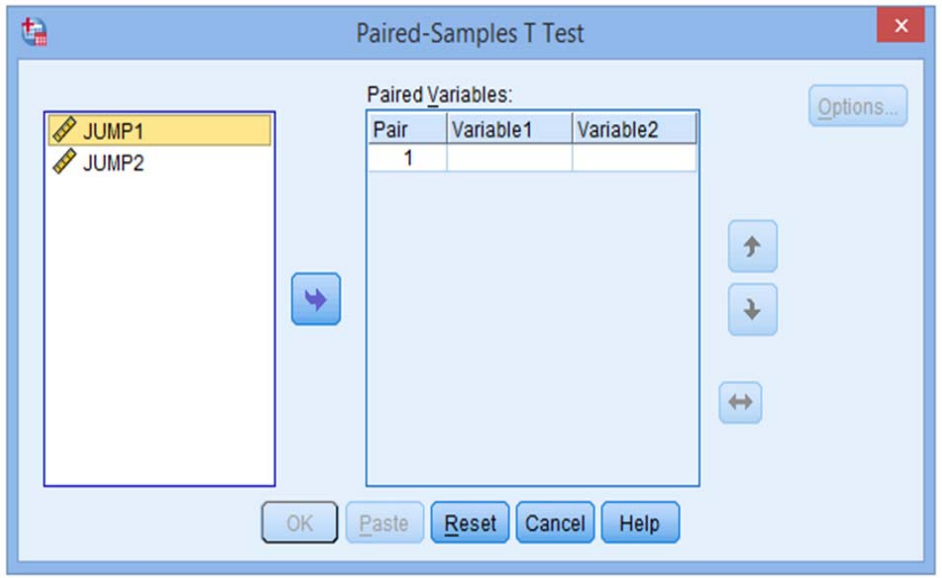
1. Click **Analyze** > **Compare Means** > **Paired-Samples T Test**



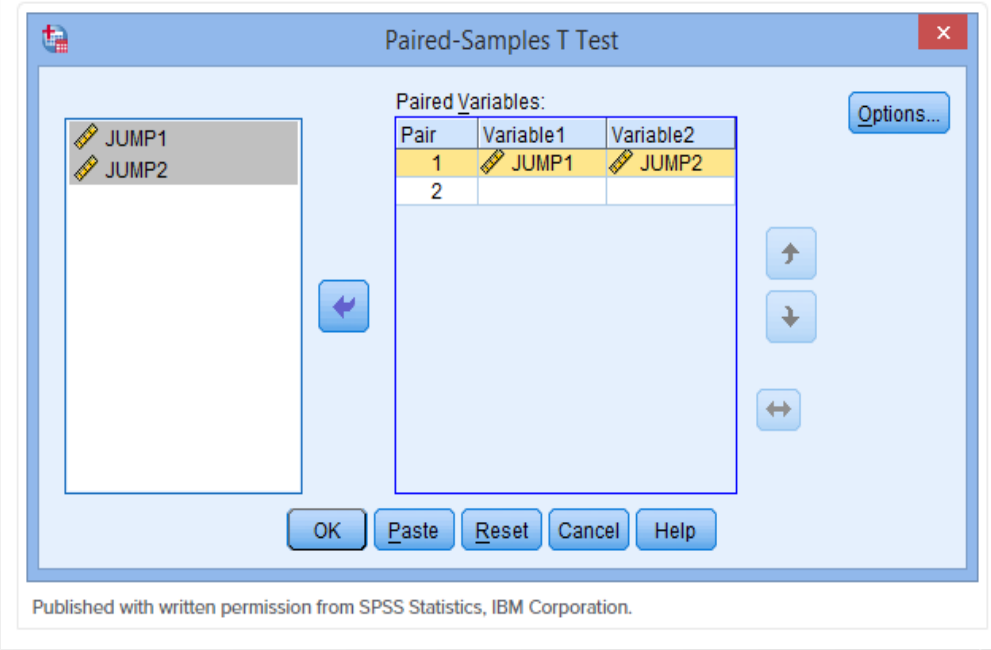
https://statistics.laerd.com/spss-tutorials/dependent-t-test-using-spss-statistics.php

Independent Sample t-test :Using SPSS

2) **Paired-Samples T Test** dialogue box, as shown below:



3) Transfer the variables JUMP1 and JUMP2 into the Paired Variables: box.



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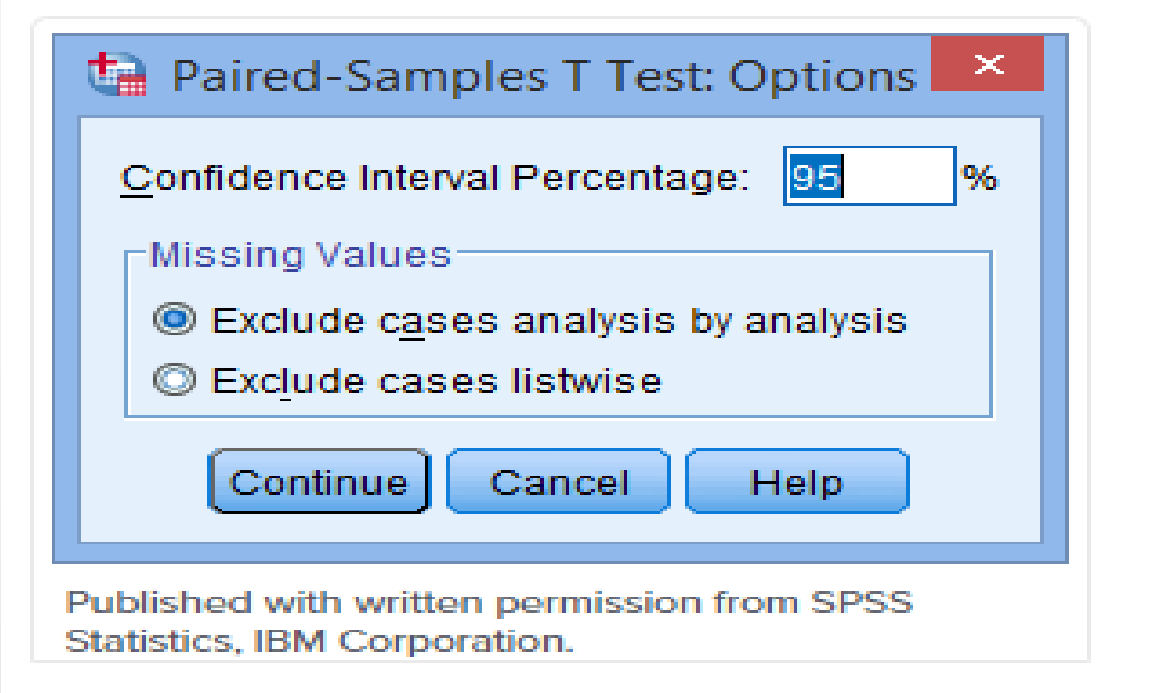
Independent Sample t-test :Using SPSS

4) click on the Options Button button. You will be presented with the **Paired-Samples T Test**: Options dialogue box, as shown below:



5) Click on the Continue button. You will be returned to the Paired-Samples T Test dialogue box.

6) Click on the OK button.

https://statistics.laerd.com/spss-tutorials/dependent-t-test-using-spss-statistics.php

Interpretation

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before	4.2000	10	1.75119	.55377
	After	4.5000	10	2.06828	.65405

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Before & After	10	.153	.672

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Before - After	-.30000	2.49666	.78951	-2.08601	1.48601	-.380	9	.713

Interpretation

How to report the result of a dependent t-test

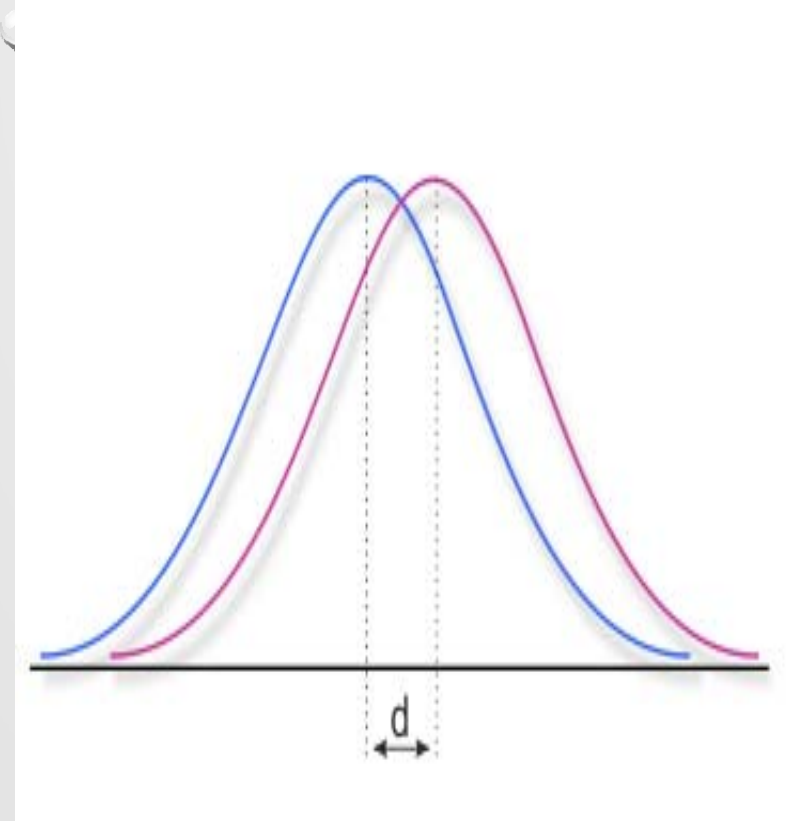
t (df) = t value, p = p value

t(9) = -0.380, P = 0.713

Since P value is greater than the alpha(0.05)

Hence, we fail to reject the Null hypotheses

Effect Size



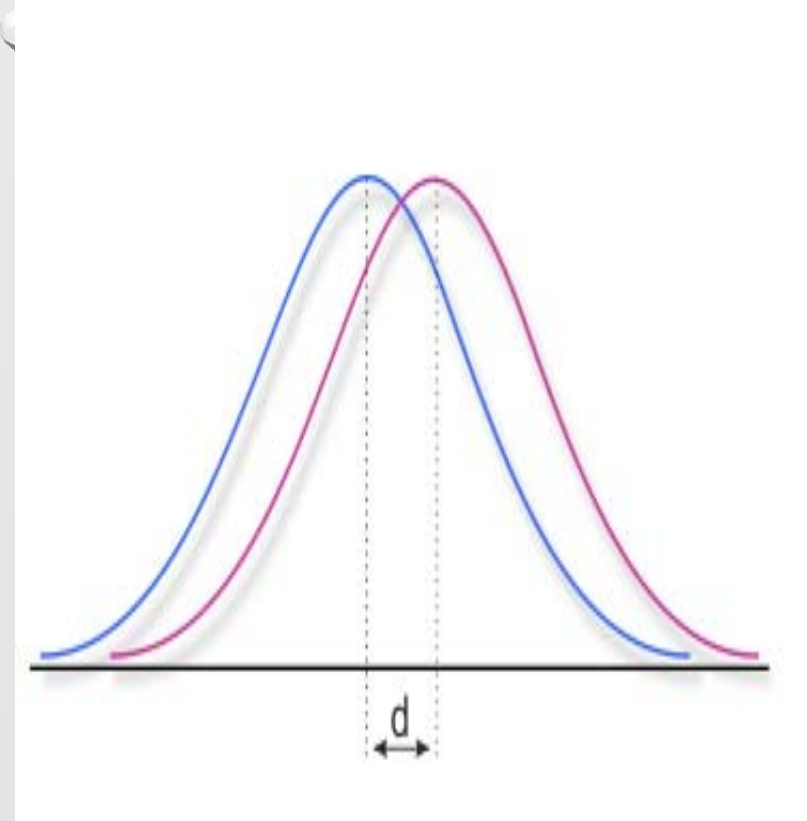
An effect size is simply an objective and standardized measure of the magnitude of observed effect
(Field,2005a,2005b)

- ✓ Effect size is a quantitative measure of the strength of a phenomenon
- ✓ Effect size emphasizes the size of the difference or relationship

Mean difference in T-test (Use Cohen's D)
d = 0.2small, d = 0.5 medium, d = 0.8 large

Mean difference in ANOVA
d = 0.01 small, d = 0.06 medium, d = 0.8 large

Effect Size



$$Effect\ size(d) = \frac{Mean}{Standard\ Deviation}$$

Cohen's (1988) Convention

0.2 = Small effect

0.5 = Medium effect

0.8 = Large effect

D = .03/2.50

= 0.12 (Small effect)

Repeated Measures ANOVA

An ANOVA with repeated measures is used to compare three or more group means where the participants are the same in each group. This usually occurs in two situations:

(1) When participants are measured multiple times to see changes to an intervention; or

(2) When participants are subjected to more than one condition/trial and the response to each of these conditions wants to be compared.

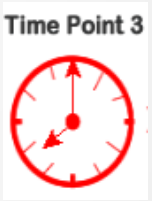
Repeated Measures ANOVA

Measure variable A
(e.g. blood pressure)

Level 1

Measure variable A
(e.g. blood pressure)

Level 2



Measure variable A
(e.g. blood pressure)

Level 3

https://statistics.laerd.com/statistical-guides/repeated-measures-anova-statistical-guide.php

The same people are in the Group

Assumptions

- ✓ Dependent variable should be measured at the continuous level
- ✓ Independent variable should consist of at least two categorical, "related groups" or "matched pairs".
- ✓ There should be no significant outliers in the related groups
- ✓ The distribution of the dependent variable in the two or more related groups should be approximately normally distributed
- ✓ **Sphericity.**

https://www.spss-tutorials.com/spss-repeated-measures-anova/

Assumption of Sphericity

- Assumption of sphericity can be likened to the assumption of homogeneity of variance (Field, 2009)

- **Sphericity** refers to the equality of variances of the differences between treatment conditions

What is the effect of violating sphericity?

- It leads to loss of power.(Increased probability of type II error)

Accessing the degree of departure from sphericity

- Mauchly's test

https://en.wikipedia.org/wiki/Mauchly%27s_sphericity_test http://www.pc.rhul.ac.uk/staff/J.Larsson/teaching/pdfs/repeatedmeasures.pdf

Repeated Measures ANOVA in SPSS

Researchers want to test a new anti-anxiety medication. They measure the anxiety of 7 participants three times: once before taking the medication, once one week after taking the medication, and once two weeks after taking medication. Anxiety is rated on a scale of 1-10,with 10 being ”high anxiety” and 1 being “low anxiety”. Are there any difference between the three condition using significant level α=0.05?

Participants	Before	Week 1	Week 2
1	9	7	4
2	8	6	3
3	7	6	2
4	8	7	3
5	8	8	4
6	9	7	3
7	8	6	2

https://www.youtube.com/watch?v=VPB3xrsFI4o

Repeated Measures ANOVA in SPSS

Null Hypothesis : There is no significant changes in anxiety level of participants before taking the medication once, one week after taking the medication once, and two weeks after taking the medication once.

Variables:

Independent variable:

Time 1(Before taking the medication once)

Time 2(One week after taking the medication once)

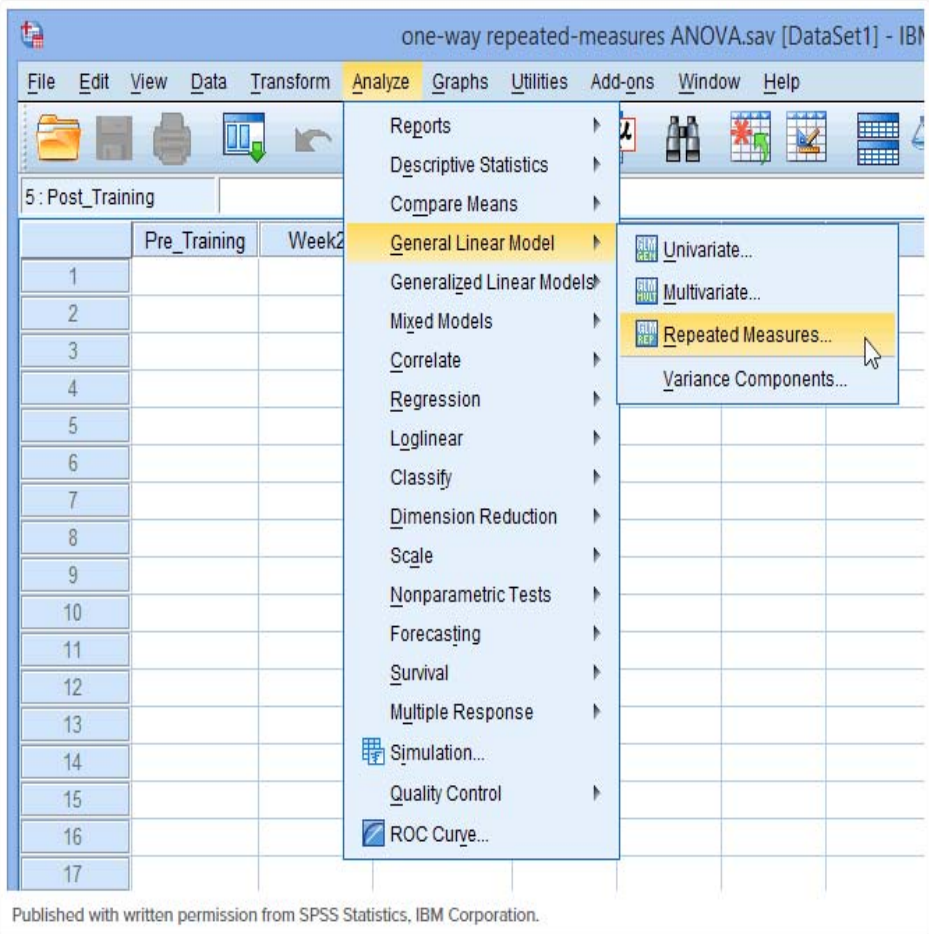
Time 3(Two weeks after taking the medication once)

Dependent variable:

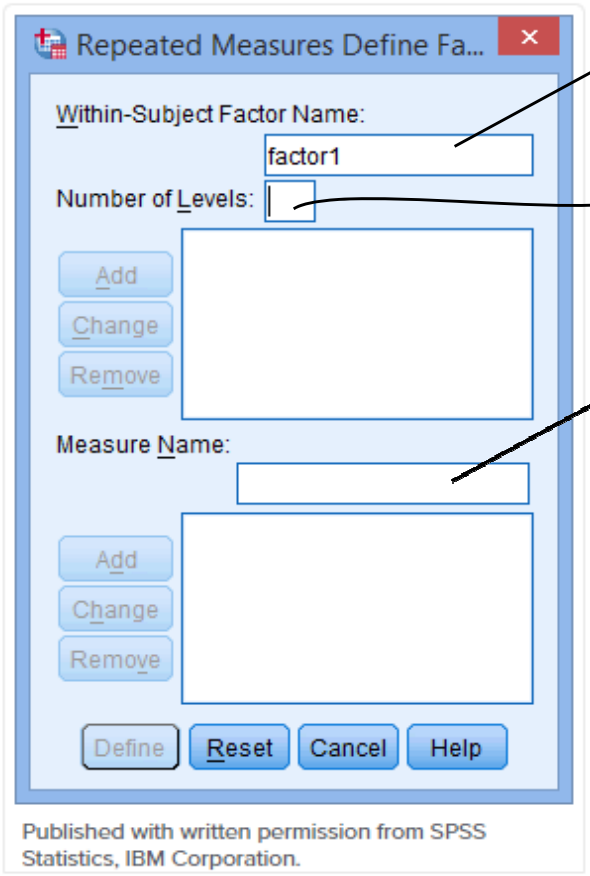
Participant's level of anxiety

level α=0.05

Repeated Measures ANOVA in SPSS



You will be presented with the following screen:



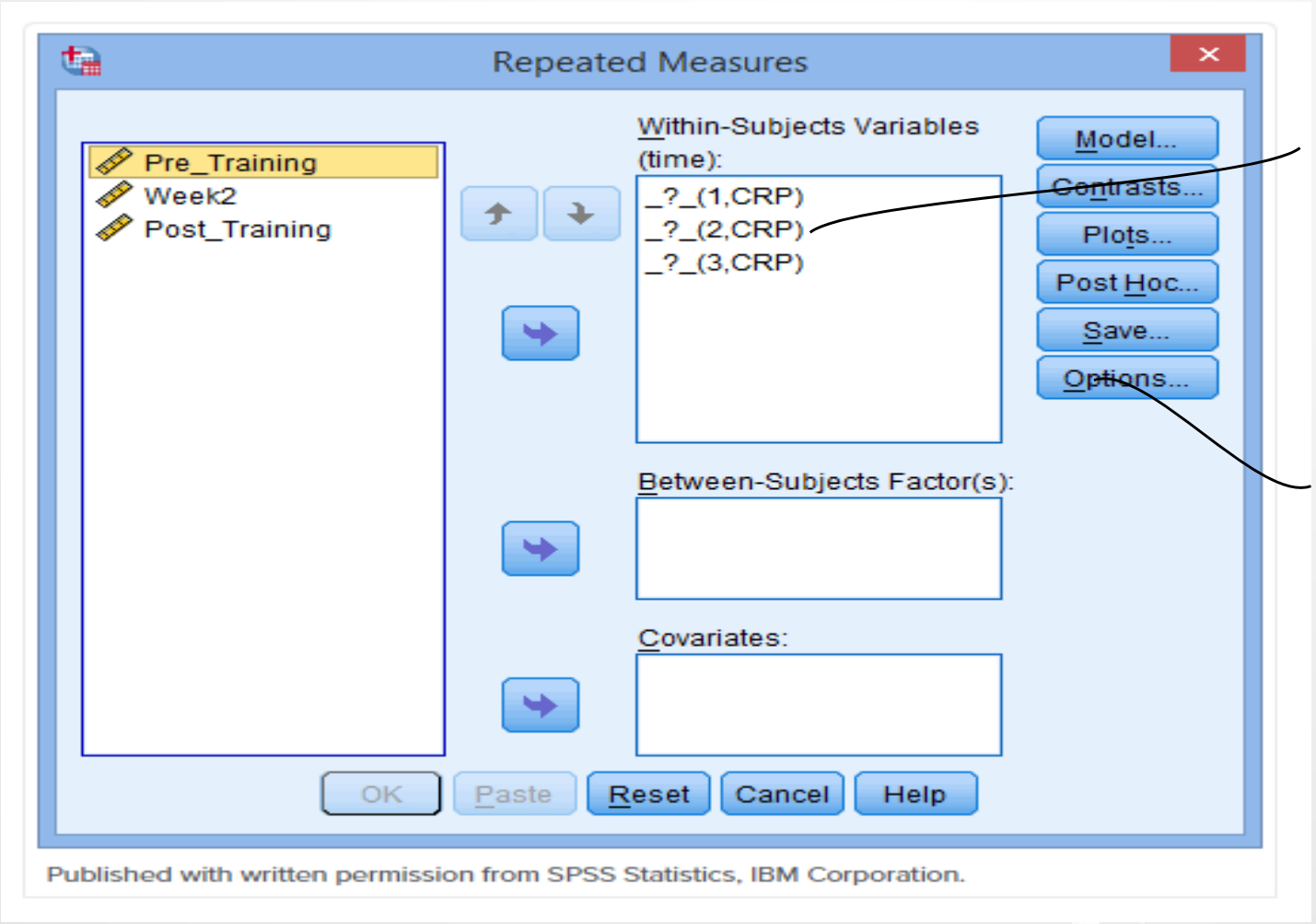
Independent variable

Number of times IV has been measured

Dependent variable

https://www.spss-tutorials.com/spss-repeated-measures-anova/

Repeated Measures ANOVA in SPSS

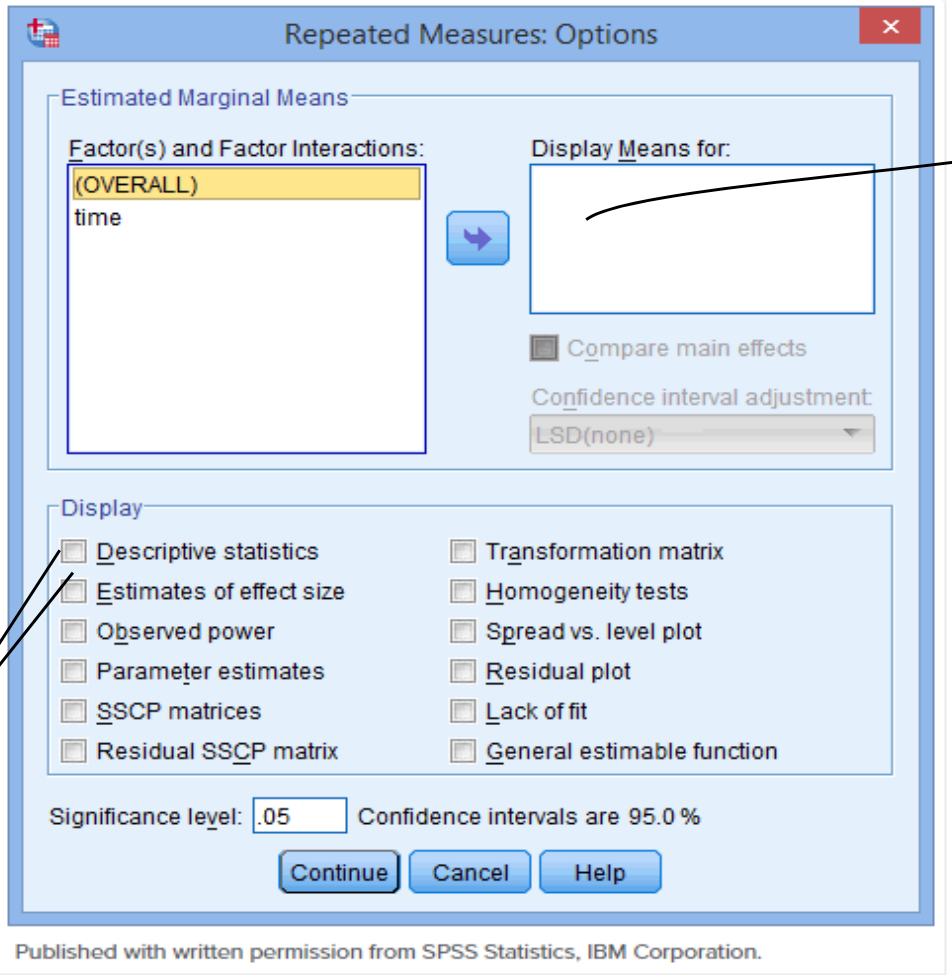


Transfer variables into the within subjects variable box

Click options

https://www.spss-tutorials.com/spss-repeated-measures-anova/

Repeated Measures ANOVA in SPSS



Transfer the factor "time" Into display box

Tick descriptive statistics and estimate of effect size

https://www.spss-tutorials.com/spss-repeated-measures-anova/

Interpretation

Mauchly's Test of Sphericity[a]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Epsilon[b] Huynh-Feldt	Epsilon[b] Lower-bound
Time	.750	1.438	2	.487	.800	1.000	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept
Within Subjects Design: Time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

As a rule of thumb, sphericity is assumed if Sig. > 0.05.

Interpretation

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Sphericity Assumed	98.667	2	49.333	222.000	.000	.974	444.000	1.000
	Greenhouse-Geisser	98.667	1.600	61.667	222.000	.000	.974	355.200	1.000
	Huynh-Feldt	98.667	2.000	49.333	222.000	.000	.974	444.000	1.000
	Lower-bound	98.667	1.000	98.667	222.000	.000	.974	222.000	1.000
Error(Time)	Sphericity Assumed	2.667	12	.222					
	Greenhouse-Geisser	2.667	9.600	.278					
	Huynh-Feldt	2.667	12.000	.222					
	Lower-bound	2.667	6.000	.444					

a. Computed using alpha = .05

F(dftime, dferror) = F-value, p = p-value

The Tests of Within-Subjects Effects is our core output.

Our p-value, Sig. = .000.

Difference between the mean is statistically significant : F(2,12) =222.00, p=0.000 η2= 0.974

Results

A one way repeated measured analysis of variance (ANOVA) was conducted to evaluate the null hypothesis that there is no change in participant's reaction to anti anxiety medication when measured before taking medications, once one week after taking medications and once two weeks after taking medication. In a group consisting of 7 participants (N=7).

The results of the ANOVA indicated a significant reaction, $F(2,12) = 222.00$, $P<0.05$, $\eta_2 = 0.974$ thus there is a significant evidence to reject the null hypothesis.

REFERENCES

Dependent T-Test - Detecting changes in time, other study designs the test can be used for, and assumptions of the test | Laerd Statistics. (n.d.). Retrieved December 18, 2019, from https://statistics.laerd.com/statistical-guides/dependent-t-test-statistical-guide-2.php

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https://www.nipissingu.ca/sites/default/files/Independent-Samples-vs-Dependent-Samples.pdf


THANK YOU